

MECHANICAL CALCULATION COVER SHEET

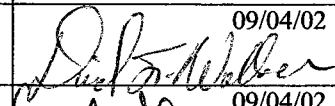
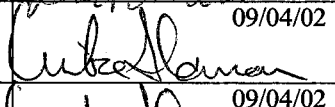
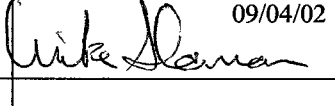
Page i of iii

Calculation No:3442.053.MCAL.004

Calculation Title: CHILLED WATER FREEZE PROTECTION

Project Title: CCN CHILLED WATER SYSTEM OPTIMIZATION MASTER PLAN

ORIGINAL AND REVISED CALCULATION/ANALYSIS APPROVAL

	Rev. _A Name/Signature/Date	Rev. B Name/Signature/Date	Rev. _0 Name/Signature/Date
Originator: DAVID WALKER			 09/04/02
Checked By: MIKE SLAMAN			 09/04/02
Approved By: MIKE SLAMAN			 09/04/02
Other:			

AFFECTED DOCUMENTS

Document Number	Document Title	Rev. Number
3442.053.MCAL.004.	LDCC EC-1 MODIFICATIONS sheets G-0001, M-0001 through M-8006, and E-0001 through E-7007.	0

Record of Revision

Rev.	Reason for Revision
REV 0	ISSUED FOR CONSTRUCTION.



CALCULATION CHECKLIST

page ii of iii

Task/Project #: 100256
Task Order 053
CCN CHILLED WATER
SYSTEM OPTIMIZATION
MASTER PLAN

Calculation Number: 3442.053.MCAL.004

Revision

0

Reviewer/Checker : MIKE SLAMAN

Date

Reviewer performed or supervised subject calculation.

☒ NO ☐ YES Justification Attachment _____, _____ pages

7/31/02

Alternate Verification method approved _____ Method _____

ITEM(S) CHECKED	Accept Y/N	OBJECTIVE EVIDENCE Sheets	INITIAL/ DATE 7/31/02
1. Cover forms properly completed.	Y		MS
2. Calculation Sheet headers complete with calc. no., rev., etc.	Y		MS
3. Calculation Sheet contents complete per format.	Y		MS
4. Listed attachments included.	N/A		
5. Calculation Objective clearly described.	Y		MS
6. Criteria are suitable and properly referenced to task-specific documents.	Y		MS
7. Assumptions and data described and attached or referenced to task documents.	Y		MS
8. Calculation method identified and appropriate for the design activity.	Y		MS
9. Calculation results reasonable and correctly described in Results and Conclusions.	Y		MS
10. Computer Program identified with version and revision.	N/A		
11. Computer Program references method used, etc.	N/A		
12. Computer input/output provided.	N/A		
13. Computer run traceable to calculation.	N/A		
14. Computer input data within permissible design input range.	N/A		
15. Computer Program validation/verification addressed.	N/A		

REMARKS

Checker Print Name & Sign
MIKE SLAMAN

Date 7/31/02

Preparer Print Name & Sign
DAVID WALKER

Date 7/31/02



Project Title: CCN CHILLED WATER
SYSTEM OPTIMIZATION MASTER PLAN

Project ID #100256

Page iii of iii

**MECHANICAL
DESIGN CALCULATION SHEET**

Calculation No.

3442.053.MCAL.004

Rev. No. 0

Calculation Title: CHILLED WATER
PIPING FREEZE PROTECTION

PERFORMED BY : David Walker
DAVID WALKER

DATE 5/01/02

CHECKED BY Mike Slaman
MIKE SLAMAN

DATE 7/31/02

INTRODUCTION

Purpose The "Statement of Work" provided from LANL dated 7/24/01 states " Provide feasibility and Title II services to connect the CCF chilled water plant to the LDCC plant such that CCF chillers will be shut down and removed and the LDCC plant will be supplying chilled water to the CCF and outlying buildings." This work requires several objectives. The first five objectives re defined in the scope listed below.

- Scope**
1. Verify that the LDCC chiller plant can adequately support the cooling loads of both LDCC and CCF plants.
 2. Develop a plan to modify the LDCC equipment room cooling system from an evaporative based system to a chilled water based system.
 3. Add a larger chilled water expansion tank to the combined chilled water systems.
 4. Modify chilled water pump impellers to match the combined chilled water pumping loads. Add backdraft dampers to air handling unit EC-1 supply fans.
 5. Evaluate the LDCC 900 Ton chiller condenser water pump and replace it if necessary.

DESIGN BASIS

- Design Inputs**
1. Test and Balance data performed by the Kirk Air Co. on 7/17/01 for CCF and Ambient Air Balance Co. for LDCC on 02/02/90.
 2. LDCC equipment room 189 cooling load calculations for LDCC Chiller Replacement Project I.D. 100015.
 3. Results from the pipe model program "Pipe Flo" created by Engineered Software INC. See Calculation M003.
 4. Manufacturers' equipment and installation requirements.

Criteria Maintain LDCC equipment room at 70 to 72°F.

Limit plant shut downs- both LDCC and CCF plant

Assumptions Future cooling loads identified under the "LDCC Chiller Replacement" project I.D. 100015 will not be realized.

Condensate piping that will be converted to chilled water piping can be properly cleaned and that the pressure drop through the piping will be minimal.

REFERENCES

Test and Balance data, and "LDCC Chiller Replacement" calculations referenced above. Also manufacturer data was used to match equipment parts to existing equipment.

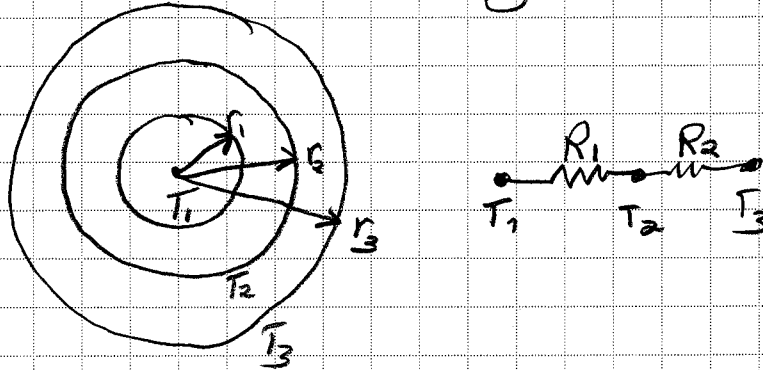
METHODS

By using equipment name plate data listed in the Test and Balance report, chilled water system temperature and pressure readings, etc., the current cooling load was determined and compared with the chiller plant equipment capacities to determine if adequate. Pump data obtained from the T&B reports were used to determine pump impeller sizes necessary to meet the pump flow rates. Field measurements were used to determine chilled water coil installation requirements. Coil was sized using manufacturer computer software.

**RESULTS AND
CONCLUSIONS**

LDCC chiller plant does have adequate capacity to serve both LDCC and CCF cooling loads. The evaporative media in air handler EC-1 can be replaced with a 4-row cooling coil and casing. The cooling coil will have to be knocked down and rebuilt inside the fan housing because it won't fit otherwise. Chilled water pump impellers can be increased in size by replacing the entire rotating elements of the pumps. The air handling unit EC-1 fans do not have anyway currently to keep air from reversing itself through the standby fans. Adding backdraft dampers to each of the four fans will not work because of space constraints in the air handling unit. Therefore the fan inlet cones will be replaced with new inlet cones that have built-in inlet vanes for damper control.

To Chilled Water Piping Freeze Protection



$$R = \frac{\ln\left(\frac{r_2}{r_1}\right)}{2\pi K_1 L} + \frac{\ln\left(\frac{r_3}{r_2}\right)}{2\pi K_2 L}$$

$$R_2 =$$

$$q = \frac{\Delta T}{R} = \frac{2\pi L (T_3 - T_1)}{\frac{\ln\left(\frac{r_2}{r_1}\right)}{K_1} + \frac{\ln\left(\frac{r_3}{r_2}\right)}{K_2}} = \frac{\text{BTU}}{\text{ft}^2 \cdot \text{h}}$$

$$\text{or } \frac{q}{L} = \frac{2\pi (T_3 - T_1)}{\frac{\ln\left(\frac{r_2}{r_1}\right)}{K_1} + \frac{\ln\left(\frac{r_3}{r_2}\right)}{K_2}} = \frac{\text{BTU}}{\text{ft} \cdot \text{ft}}$$

$$T_1 = 44^\circ \text{F}$$

$$T_3 = 5^\circ \text{F}$$

$$K_1 = 26.2 \frac{\text{BTU}}{\text{h} \cdot \text{ft} \cdot ^\circ \text{F}}$$

$$r_1 = 4.026''/2 \times \frac{\text{ft}}{12 \text{ in}} = .168 \text{ ft}$$

$$r_2 = 4.50''/2 \times \frac{\text{ft}}{12 \text{ in}} = .188 \text{ ft}$$

$$r_3 = 6.50''/2 \times \frac{\text{ft}}{12 \text{ in}} = .271 \text{ ft}$$

$$K_2 = .23 \frac{\text{BTU} \cdot \text{in}}{\text{h} \cdot \text{ft}^2 \cdot ^\circ \text{F}} = .23 \frac{\text{BTU} \cdot \text{in}}{\text{h} \cdot \text{ft}^2 \cdot ^\circ \text{F}} \times \frac{\text{ft}}{12 \text{ in}} = .019 \frac{\text{BTU}}{\text{h} \cdot \text{ft} \cdot ^\circ \text{F}}$$

3442.053, MCL, 004 Rev 0

$$\frac{q}{L} = \frac{2\pi(5^\circ - 44^\circ F)}{\ln\left(\frac{.188}{.168}\right) + \ln\left(\frac{.271}{.168}\right)} = 12.73 \frac{\text{BTU}}{\text{h} \cdot \text{ft}}$$

$$= \frac{26.2 \frac{\text{BTU}}{\text{h} \cdot \text{ft} \cdot ^\circ\text{F}}}{.019 \frac{\text{BTU}}{\text{h} \cdot \text{ft} \cdot ^\circ\text{F}}} = 3.73 \frac{\text{Watts}}{\text{ft.}}$$

Units: $\frac{\text{Watts}}{\text{h} \cdot \text{ft} \cdot ^\circ\text{F}}$ ✓

Check: Based on Chromalox Design Guide
Table 1 Pg. 5

Pipe size = 4"

Insulation = 1" and 1 1/2"

Heat Loss = .115 and .083 W/ft.°F

= 4.49 and 3.24 W/ft @ 39°F ΔT (44°-5°)

1. ΔT = 44°F - 5°F = 39°F

2. Q_e = .115 W/ft.°F × 39°F = 4.49 W/ft

3. Table 1 Based on 20 mph wind.
Add another 10% For 30 mph

Q = 4.49 × 1.1 = 4.94 W/ft use 5.0 W/ft

3442.053. HCAL. 004 Rev 0

Chromalox[®]

PRECISION HEAT AND CONTROL

Electrical Heat Tracing Systems

Design Guide



3442.053.MCAL.004, Rev0

Chromalox®

Industrial Heat Tracing System Design

Table 1 — Heat Losses from Insulated Metal Pipes
W/Ft. of Pipe per °F Temperature Differential

Pipe Size (IPS)	Insulation Thickness (In.)							
	1/2	3/4	1	1-1/2	2	2-1/2	3	4
1/2	0.054	0.041	0.035	0.028	0.024	0.022	0.020	0.018
3/4	0.063	0.048	0.040	0.031	0.027	0.024	0.022	0.020
1	0.075	0.055	0.046	0.036	0.030	0.027	0.025	0.022
1-1/4	0.090	0.066	0.053	0.041	0.034	0.030	0.028	0.024
1-1/2	0.104	0.075	0.061	0.046	0.038	0.034	0.030	0.026
2	0.120	0.086	0.069	0.052	0.043	0.037	0.033	0.029
2-1/2	0.141	0.101	0.080	0.059	0.048	0.042	0.037	0.032
3	0.168	0.118	0.093	0.068	0.055	0.048	0.042	0.035
3-1/2	0.189	0.133	0.104	0.075	0.061	0.052	0.046	0.038
4	0.210	0.147	0.115	0.083	0.066	0.056	0.050	0.041
4-1/2	0.231	0.161	0.125	0.090	0.072	0.061	0.054	0.044
5	0.255	0.177	0.137	0.098	0.078	0.066	0.058	0.047
6	0.300	0.207	0.160	0.113	0.089	0.075	0.065	0.053
7	0.342	0.235	0.181	0.127	0.100	0.084	0.073	0.059
8	0.385	0.263	0.202	0.141	0.111	0.092	0.080	0.064
9	0.427	0.291	0.222	0.156	0.121	0.101	0.087	0.070
10	0.474	0.323	0.247	0.171	0.133	0.110	0.095	0.076
12	0.559	0.379	0.290	0.200	0.155	0.128	0.109	0.087
14	0.612	0.415	0.316	0.217	0.168	0.138	0.118	0.093
16	0.696	0.471	0.358	0.246	0.189	0.155	0.133	0.104
18	0.781	0.527	0.401	0.274	0.210	0.172	0.147	0.115
20	0.865	0.584	0.443	0.302	0.231	0.189	0.161	0.125
24	1.034	0.696	0.527	0.358	0.274	0.226	0.189	0.147
Tank	0.161	0.107	0.081	0.054	0.040	0.032	0.027	0.020

Values in Table 1 are based on the following formulas plus 10% safety margin.
The K factor of 0.25 for Fiberglass® at 50°F is assumed.

Watts/Ft. of pipe = $2 \pi k (\Delta T) + (Z \ln. (D_o/D_i))$
 where K = Thermal conductivity
 BTU x In./Hr. x Ft² x °F
 D_o = Outside diameter of insulation (In.)
 D_i = Inside diameter of insulation (In.)
 ΔT = Temperature differential (°F)
 Z = 40.944 BTU x In./W x Hr. x Ft.

Watts/Sq. Ft. = $Y k (\Delta T) + X$
 where K = Thermal conductivity
 (BTU x In./Hr. x Ft² x °F)
 X = Thickness of insulation (In.)
 Y = 0.293 W x Hr./BTU

Table 2 — K Factor Chart for Various Insulation Types*

Temperature (°F)	0	50	100	150	200	250	300	350	400
Fiberglass	0.23	0.25	0.27	0.29	0.32	0.34	0.37	0.39	0.41
Calcium Silicate	0.35	0.37	0.40	0.43	0.45	0.47	0.50	0.53	0.55
Urethane	0.18	0.17	0.18	0.22	0.25	—	—	—	—
Cellular Glass	0.38	0.40	0.46	0.50	0.55	0.58	0.61	0.65	0.70

*Select the K factor equal to or below the maintenance temperature for K_{Tm} or the K factor equal to or below the ambient temperature for K_{Ta} .

Pipe Example:

T_m = 100°F
 T_s = 40°F
 T_a = 0°F
 Pipe Size = 2 inches
 Insulation = Fiberglass®
 Thickness = 1 inch
 Wind speed = 20 MPH
 Location = Outdoor
 H.L.S.F. = 10%

- $\Delta T = 100^\circ\text{F} - 0^\circ\text{F} = 100^\circ\text{F}$
- $Q_p = 0.069 \text{ W/(Ft. } ^\circ\text{F)}$
- $Q = (0.069) \times 100$
- A. $Q = 6.90 \times 2 \times (0.27 + 0.23)$
 B. Table 1 based on 20 MPH wind.
 No additional heat loss.
 C. Location is outdoors.
 D. Table 1 includes a 10% safety factor.

Results: $Q = 6.90 \text{ W/Ft.}$

Tank Example:

Maintain a metal tank with 2 inches of Fiberglass® insulation at 50°F. The tank is cylindrical and is 4 feet in diameter and 12 feet long. The minimum ambient temperature is 0°F and the maximum expected wind speed is 15 MPH.

- $\Delta T = 50^\circ\text{F} - 0^\circ\text{F} = 50^\circ\text{F}$
- $Q_t = 0.040 \text{ W/Ft}^2 \times ^\circ\text{F}$
- $Q = (0.040) \times (50) = 2.0 \text{ W/Ft}^2$
- A. $Q = (2.0 \times 2) \times (0.25 + 0.23) = 1.92 \text{ W/Ft}^2$
 B. No Adjustments
 C. No Adjustments
 D. No Adjustments
- A. Surface area (SA) = $\pi \times 4 \times (2 + 12) = 175.9 \text{ Ft}^2$
 B. $W = 175.9 \text{ Ft}^2 \times 1.92 \text{ W/Ft}^2 = 337.7 \text{ Watts}$

3442.053.MCAL.004
Rev D